Med & Health Jul 2025; 20(2): 432-452 https://doi.org/10.17576/MH.2025.2002.02

REVIEW ARTICLE

Effectiveness of COMBI in Dengue Prevention and Control and Participation Factor: A Systematic Review in Malaysia

AHMAD FARID NAZMI ABDUL HALIM[1], MOHD ROHAIZAT HASSAN[1]*, ROZITA HOD[1], KHAIRONI YATIM SHARIF[2], NOOR KHALILI MOHD ALI[3], RAHMAT DAPARI[4], SYED SHARIZMAN SYED ABDUL RAHIM[5], MOHD 'AMMAR IHSAN AHMAD ZAMZURI[6], MOHD NAZRIN JAMHARI[7], SHAHRUL AZHAR MD HANIF[1], QISTINA MOHD GHAZALI[1]

[1]*Department of Public Health Medicine, Faculty of Medicine, Universiti Kebangsaan Malaysia, 56000 Cheras, Kuala Lumpur, Malaysia*

[2]*Department of Computer & Information Science, Faculty of Science and Information Technology, Universiti Teknologi Petronas, 32610 Seri Iskandar, Perak, Malaysia*

[3]*Seremban District Health Office, Seremban, 70590 Negeri Sembilan, Malaysia*

[4]*Department of Community Health, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia*

[5]*Department of Public Health Medicine, Faculty of Medicine and Health Sciences, Universiti Malaysia Sabah, 88400 Kota Kinabalu, Sabah, Malaysia*

[6]*Negeri Sembilan Health Department, 70300 Seremban, Negeri Sembilan, Malaysia*

[7]*Kubang Pasu District Health Office, 06000 Jitra, Kedah, Malaysia*

Received: 14 September 2024 / Accepted: 08 November 2024

ABSTRAK

Kebanyakan strategi pencegahan, kawalan dan mitigasi penyakit bergantung kepada penglibatan, penyertaan dan pemilikan komuniti. Oleh demikian, intervensi tingkah laku dan sosial merupakan aspek penting dalam usaha mitigasi wabak. Strategi mobilisasi sosial dan komuniti (COMBI) telah dilaksanakan di Malaysia untuk menggerakkan komuniti sebagai agen utama dalam mencegah penularan denggi. Ulasan sistematik ini bertujuan untuk menilai keberkesanan COMBI dalam pencegahan dan kawalan denggi di Malaysia serta mengenal pasti faktor-faktor yang mempengaruhi penyertaan dalam COMBI. Ulasan sistematik ini didaftarkan dengan pangkalan data PROSPERO (CRD42022341967) dan dilaporkan berdasarkan garis panduan PRISMA. Artikel asal yang diterbitkan dalam Bahasa Inggeris dari tahun 2001 hingga 2023, yang melaporkan tahap pengetahuan, sikap, dan amalan (KAP) dan/atau indeks entomologi, serta faktor-faktor yang mempengaruhi penyertaan dalam COMBI di Malaysia, telah dikumpulkan secara elektronik daripada empat pangkalan data. Kualiti artikel yang diperolehi dinilai menggunakan Alat Penilaian Kaedah Campuran (MMAT). Empat artikel telah dipilih dalam ulasan ini, yang merangkumi reka bentuk kajian kuantitatif dan

Address for correspondence and reprint requests: Mohd Rohaizat Hassan. Department of Public Health Medicine, Faculty of Medicine, Universiti Kebangsaan Malaysia, Jalan Yaacob Latif, Bandar Tun Razak, 56000 Cheras, Kuala Lumpur, Malaysia. Tel: +6012-6343303 E-mail: rohaizat@hctm.ukm.edu.my

kualitatif. Hasil dapatan menunjukkan bahawa COMBI berupaya meningkatkan tahap KAP dan mengurangkan kepadatan vektor semasa tempoh pelaksanaan aktif. Faktor-faktor yang menghalang penyertaan dalam COMBI dan kemampanannya termasuk kepimpinan yang lemah dan kurang komitmen di peringkat komuniti, serta kekurangan publisiti dan pemantauan oleh pihak berkuasa kesihatan akibat sumber yang terhad. Lebih banyak kajian diperlukan untuk memberikan bukti impak dalam situasi sebenar. Kajian tersebut juga perlu mengukur kesan COMBI terhadap bebanan jangkitan denggi. Selain itu, strategi pelaksanaan baru perlu diterokai bagi memastikan penyertaan aktif dalam COMBI dan seterusnya mencapai kemampanan.
Kata kunci: *COMBI; denggi; keberkesanan; kemampanan; penyertaan*

ABSTRACT

Most of the disease prevention, control and mitigation strategies rely heavily on community engagement, participation and ownership. Thus, behavioural and social interventions have become essential to outbreak mitigation efforts. The Communication for Behavioural Impact (COMBI) approach has been implemented in Malaysia to mobilise the community as the primary agent to prevent dengue transmission. This systematic review aimed to assess the effectiveness of COMBI in dengue prevention and control within Malaysia and identify factors influencing participation therein. This systematic review was registered with the PROSPERO database (CRD42022341967) and reported based on the PRISMA guideline. Original articles published in English from 2001 to 2023, reporting the level of knowledge, attitude and practice (KAP) and/or entomological indices, as well as factors influencing COMBI participation in Malaysia, were collected electronically from four databases. The mixed methods appraisal tool (MMAT) was used to evaluate the quality of the included articles. Four articles were included in this review, encompassing quantitative and qualitative study designs. They showed that COMBI had improved the level of KAP and reduced the presence of vectors during the active implementation period. Factors hindering participation in COMBI and its sustainability included poor leadership and commitment at the community level, as well as a lack of publicity and monitoring by health authorities due to limited resources. More well-conducted cluster randomised controlled trials are needed to provide evidence of real-life impact. Such trials should also measure COMBI's impact on dengue infection. Additionally, new implementation strategies must be explored to maintain active participation in COMBI and achieve sustainability.
Keywords: COMBI; dengue; effectiveness; participation; sustainability

INTRODUCTION

Dengue virus (DENV) is a single-stranded RNA virus with four serotypes (DENV-1–4) that causes dengue fever. The virus is transmitted by *Aedes aegypti* and *Aedes albopictus* mosquitoes and in specific regions, by other species of the genus *Aedes* (Simmons et al. 2012). The global dengue incidence has increased 30-fold in the last 50 years, and more than half of the world's population is at risk of contracting dengue fever (Pang et al. 2017). Cases of dengue infection reported to the World Health Organisation (WHO) increased from 505,430 cases in 2000 to 5.2

million in 2019 (WHO 2024). A model by Bhatt and colleagues (2013) estimated the occurrence of 390 million dengue infections worldwide each year, of which 96 million are symptomatic. They also estimated that 70% of these infections occur in Asia, 14% in the Americas, 16% in Africa, and only 0.2% in Oceania (Bhatt et al. 2013).

Dengue has been endemic in Malaysia since the 1970s, with outbreaks of increasing intensity and magnitude in recent decades. The first dengue fever outbreak in Malaysia was reported in Penang in 1962, with 41 cases and five deaths reported (Rose Nani 2015). Dengue is considered a serious public health problem in Malaysia, with a high morbidity and mortality rate (Mohd-Zaki et al. 2014). Due to rapid population growth and the influx of foreign workers (Yi et al. 2020), the exact number of dengue cases in Malaysia is underreported (Undurraga et al. 2013). The total number of dengue cases in Malaysia has increased from 7,103 cases in 2000 to a peak of 130,101 cases in 2019 (AbuBakar et al. 2022). Given the last peak in 2019 and based on a cyclical pattern with peaks every 4-5 years, dengue incidence is expected to peak again in Malaysia in 2023 or 2024 (AbuBakar et al. 2022).

To address this issue, the Ministry of Health in Malaysia has introduced the National Dengue Strategic Plan (NDSP) 2022-2026. This comprehensive plan includes three pillars: strengthening dengue surveillance, enhancing access to diagnosis and treatment, and intensifying efforts in prevention and control. To support the NDSP, the government is committed to improving the healthcare system and fostering research and innovation in dengue-related fields (MOH 2022).

To date, since there is no definitive treatment for dengue fever, only supportive treatments have been used to treat the disease and avoid the risk of death (Kalayanarooj et al. 2017; Othman et al. 2017). Moreover, safe and effective vaccines for dengue are lacking (Scott & Morrison 2010; Stanaway et al. 2016; WHO 2017). Thus, measures to prevent the transmission of dengue fever remain focused on vector control interventions (WHO 2009). As the presence of *Aedes aegypti* depends on human behaviour, there is a growing need for community involvement in vector control. Hence, to control dengue, simple, cost-effective, community-led, and sustainable solutions to reduce vector abundance are required (Murray et al. 2013).

Various vector control strategies, including chemical, biological, and physical interventions, have been used for decades; these are highly reliant on community acceptance (Liverani et al. 2017; WHO 2024). Thus, communities must be active partners in vector control program planning, implementation, monitoring and evaluation activities (Toledo Romani et al. 2007; Vanlerberghe et al. 2009; Wai et al. 2012). Integrated vector management (IVM) is an approach to ensure the involvement of the community, together with other stakeholders, in designing and implementing dengue control strategies based on local evidence (Caprara et al. 2015; Kittayapong et al. 2012; Lima et al. 2015; WHO 2012a). It promotes community acceptance and ownership and ensures sustained community participation in dengue prevention and control activities (Parks et al. 2004; Renganathan et al. 2003).

Multipronged, culturally appropriate behaviour change communication approaches are crucial parts of IVM to increase awareness and empower the community to prevent dengue (Khun & Manderson 2007). Various advocacy and social mobilisation initiatives have been implemented to involve the community as the primary agent to prevent dengue transmission in Malaysia, including Communication for

Behavioural Impact (COMBI), which was introduced by the WHO in 2001. COMBI has been advocated as essential to achieving effective dengue prevention by actively involving the community in intervention design, planning, and implementation, as well as developing communication strategies and education materials to reach out to different target audiences (WHO 2008). COMBI has been a key component of efforts to reduce dengue outbreaks, as prevention activities are highly dependent on community involvement (WHO 2012b). It is one of the social mobilisation and communication approaches used to empower individuals, families and communities for healthy behaviour change. Its implementation demands active participation from the community.

COMBI has been applied for the control of tuberculosis in Bangladesh, India, and Kenya; lymphatic filariasis in Nepal, Sri Lanka, and Zanzibar; and leprosy in Mozambique (WHO 2012b). In Malaysia, the COMBI approach was initially implemented in Johor to control dengue. It was launched in August 2001 as a pilot project and sustained for 12 weeks (Suhaili et al. 2004). Since then, Malaysian health authorities have made intensive efforts to educate the public on dengue. COMBI activities include local stakeholder engagement in discussions of problems and activity planning; community mobilisation in prevention and dissemination activities; household visits to support their efforts to reduce mosquito breeding sites; educational programs at the household and community levels; partnerships with local services; and efforts to improve local services such as garbage collection and disposal (Suhaili et al. 2004). These activities have been implemented throughout Malaysia under the coordination of district health authorities.

The study of COMBI in Malaysia is warranted for three compelling reasons. First, COMBI has become synonymous with dengue prevention and control in the country, showcasing its consistency in community engagement and behaviour change for combating dengue. Second, COMBI's unique application for dengue prevention in Malaysia, tailored to the country's diverse population and cultural context, makes it valuable for study. Third, in contrast to other countries where COMBI may be applied for various diseases, Malaysia's focus on COMBI for dengue prevention highlights its specialisation and unique effectiveness in addressing a specific and pressing public health concern.

Although it has been established for years, to our knowledge, no systematic review has evaluated the COMBI approach to dengue prevention. Previous systematic reviews focused on the effectiveness of community-oriented interventions in reducing vector populations for dengue control (Heintze et al. 2007). This systematic review aimed to assess the effectiveness of the COMBI approach in dengue prevention and control within Malaysia. We also aimed to identify factors influencing community participation in the COMBI program. This work focuses on the Malaysian context, offering insights into COMBI's efficacy and community engagement dynamics that are specific to this multicultural and multilingual environment. The results primarily apply to Malaysia due to its unique application of COMBI to dengue and community engagement. This review not only help to determine the impact of the COMBI program but also assist the government and policymakers in formulating strategies to fill gaps in its implementation and delivery.

MATERIALS AND METHODS

This systematic review was registered with

the International Prospective Register of Systematic Reviews (PROSPERO) database (CRD42022341967) and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (Page et al. 2021). The review question was developed using the population, intervention, comparator, outcome (PICO) framework (Munn et al. 2018). This framework is commonly used to assess the impact of an intervention or practice on outcomes (Munn et al. 2018). In this study, the PICO components were as follows: (i) Population: residents involved in COMBI in Malaysia; (ii) Intervention: COMBI; and (iii) Outcome: the effectiveness of COMBI and factors that influence COMBI participation. However, no comparator was included. The main review questions were as follows: (i) What is the level of knowledge, attitudes and practices (KAP) regarding dengue prevention before and after COMBI implementation?; (ii) What are the entomological indices before and after COMBI implementation?; and (iii) What are the factors associated with COMBI participation?

Search Strategy

The literature search was conducted in January 2024, using four databases: Cochrane (Wiley), Web of Science, PubMed and Scopus. Table 1 showed the search strategy and keywords used to identify articles relevant to the review questions.

Eligibility Criteria

The inclusion criteria were as follows: (i) original articles investigating the effectiveness of COMBI (any study with empirical data reporting level of KAP and/or entomological indices) and factors influencing COMBI participation; (ii) publications in the English language from 1st January 2001 to 31st December 2023; and (iii) studies conducted in Malaysia. Review articles and opinion papers were excluded. The chosen publication period started in 2001 as this year marked the introduction of COMBI.

TABLE 1: Search strategy and keywords used

Number	Search term	Review question
1	"communication for behavioural impact" OR "COMBI" OR "community-based intervention"	1
2	"dengue"	
3	"knowledge" OR "attitude" OR "practice" OR "KAP" OR "effectiveness"	
4	1 AND 2 AND 3	
5	"entomological indices" OR "Aedes index" OR "Breteau index" OR "ovitrap index" OR "house index" OR "container index"	2
6	1 AND 2 AND 5	
7	"associated factors" OR "predictor" OR "determinant" OR "correlate" OR "characteristics" OR "participation"	3
8	1 AND 2 AND 7	

Study Selection

The retrieved articles were imported into the EndNoteX7 (Clarivate Analytics, Philadelphia, USA) library and library de-duplication was performed (Bramer et al. 2016). Articles were screened in three stages before their inclusion in the review (Jane Ling et al. 2023). In the first stage, articles that were not relevant to the review questions based on title screening were removed. Then, the abstracts of the remaining papers were reviewed, and irrelevant publications were eliminated. In the last stage, the full-text articles were carefully reviewed to exclude studies that did not meet the inclusion criteria. Studies with insufficient data were excluded as well. AFNAH and MRH screened the titles, abstracts and full-text articles independently. Any disagreements were resolved through discussion with RH, KYS, and NKMA to reach a consensus. This process was summarised in a PRISMA flow diagram detailing the number of studies rejected and retained at each step (Figure 1).

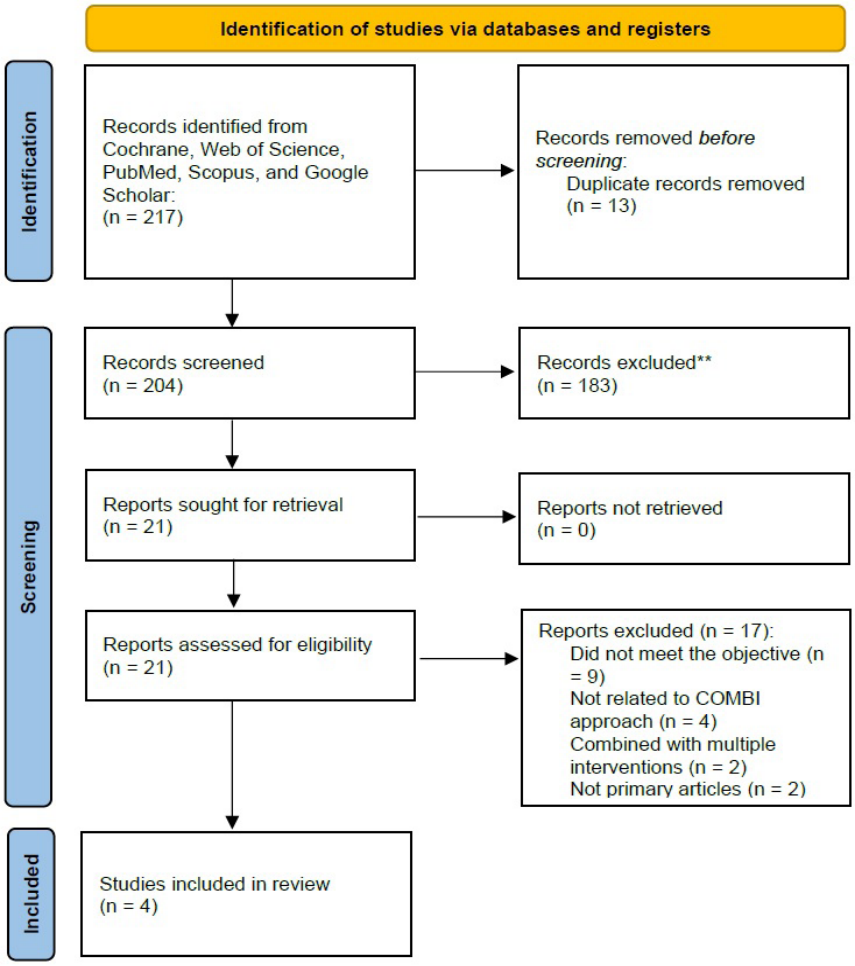

FIGURE 1: PRISMA flow diagram

Quality Assessment

Five reviewers (AFNAH, MRH, RH, KYS, and NKMA) independently used the Mixed Methods Appraisal Tool (MMAT) to appraise the quality of all included studies (Hong et al. 2018). This tool can be used to assess the methodological quality of five categories of studies (qualitative, quantitative randomised controlled, quantitative non-randomised, quantitative descriptive and mixed methods) using five criteria for each category. Any disagreements that arose during the assessment were resolved by discussion.

Data Extraction and Synthesis

The data were extracted by AFNAH and MRH. Any conflicts among extractors were resolved through discussion with RH, KYS and NKMA to reach a consensus. The information collected included (i) author; (ii) publication year; (iii) reference; (iv) study objective; (v) study design; (vi) study location; (vii) sample size; and (viii) timeline/intervention period. The outcomes retrieved from the selected articles included the level of KAP and entomological surveys, including the primary mosquito vector, *Aedes* index (percentage of houses positive for *Aedes* larvae), Breteau index (number of containers positive for *Aedes* larvae per 100 premises inspected), and ovitrap index (percentage of ovitraps containing eggs), as well as factors associated with COMBI participation. Due to the heterogeneity of the included studies regarding outcome measures, it was impossible to conduct a meta-analysis. Therefore, a narrative summary was used to present the findings.

RESULTS

Search Results

The search strategy produced a total of 217 records, which was reduced to 204 after duplicate removal. A further 183 records were excluded after screening the titles and abstracts, leaving 21 records. The full texts of the remaining records were retrieved for eligibility assessment. Nine articles were excluded because they did not meet the objective (n = 9) (Banneheke et al. 2016; Bigio et al. 2022; Elsinga et al. 2018; Hanh et al. 2009; Kumaran et al. 2018; Lin et al. 2016; Mitchell-Foster et al. 2015; Sombié et al. 2020; Wai et al. 2012), foure were not related to the COMBI approach (n = 4) (Bonnet et al. 2020; Elsinga et al. 2017; Ouédraogo et al. 2018; Pérez et al. 2013), two combined multiple interventions (n = 2) (Hustedt et al. 2021; Shafique et al. 2019), and two were not primary/original research articles (n = 2) (Suhaili et al. 2004; Tapia-Conyer et al. 2012), leaving a total of four articles for quality appraisal. The PRISMA flowchart was presented in Figure 1.

Quality Appraisal

The quality of all the included articles ranked high. They all provided a clear statement of their objectives and used appropriate data collection approaches to answer their research questions. A summary of the quality assessment was presented in Table 2.

Background of the Eligible Studies

A total of four studies were included in this systematic review (Hod et al. 2013; Mohammed Nawi et al. 2015; Rozhan et al. 2006; Suraiya et al. 2016). All the studies were conducted in Malaysia, and the specific location for each study was either urban or suburban. The

TABLE 2: Details of the MMAT assessment

Author	Type of study	Is the sampling strategy relevant to address the research question?	Is the sample representative of the target population?	Are the measurements appropriate?	Is the risk of nonresponse bias low?	Is the statistical analysis appropriate to answer the research question?
Rozhan et al. (2006)	Quantitative descriptive	Yes	Yes	Yes	Not sure	Yes
Hod et al. (2013)	Quantitative descriptive	Yes	Yes	Yes	Yes	Yes
		Is the qualitative approach appropriate to answer the research question?	**Are the qualitative data collection methods adequate to address the research question?**	**Are the findings adequately derived from the data?**	**Is the interpretation of results sufficiently substantiated the data?**	**Is there coherence between qualitative data sources, collection, analysis and interpretation?**
Suraiya et al. (2016)	Qualitative	Yes	Yes	Yes	Yes	Yes
		Is there an adequate rationale for using a mixed methods design to address the research question?	**Are the different components of the study Effectively integrated to answer the research question?**	**Are the outputs of the integration of qualitative and quantitative component adequately interpreted?**	**Are the divergences and inconsistencies between quantitative and qualitative results adequately addresses?**	**Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?**
Mohammed Nawi et al. (2015)	Mixed method	Yes	Yes	Yes	Yes	Yes

included articles were published between 2006 and 2016. Collectively, these articles reported on the effectiveness of the COMBI program and factors that influence COMBI participation. Two of the included studies were quantitative studies (cross-sectional) and one study each was of qualitative and mixed-method design. Two studies each explored the level of KAP, entomological indices and factors associated with COMBI participation. Table 3 showed the characteristics of the included studies, including their objective, study design, location, sample size/premise and timeline/ intervention period. Table 4 summarised the outcomes retrieved from the articles, including the level of KAP, entomological surveys and factors associated with COMBI participation.

Level of Knowledge, Attitude and Practice

Hod et al. (2013) conducted a cross-sectional study in Nilai to determine the effectiveness of COMBI using a KAP questionnaire following COMBI implementation from November 2011 to March 2012. Information was collected from 106 respondents before and immediately after the intervention. The establishment of COMBI promoted teams, clean-up programs, a talk show with the residential communities, and the distribution of dengue brochures to residents were among the activities that were carried out. The study's findings revealed a significant difference in the KAP level regarding dengue among the residents before and after the intervention. Hence, COMBI was effective in improving the KAP level in the target population.

On the other hand, Mohammed Nawi et al. (2015) found that the target population's average score for knowledge and attitude was marginally higher than that of the control population, but the difference was not statistically significant. This observation might be attributed to selection bias due to inter-state migration for various reasons. The study which was conducted from June 2008 to December 2008, included 160 respondents from the target population and 154 control respondents and aimed to evaluate the impact of the COMBI program in Hulu Langat following its implementation in 2004. The justification for the study was that no post-COMBI program assessment study had been performed to measure the KAP level in Hulu Langat. However, the method used in this quantitative study (self-administered questionnaires) provides room for information bias, wherein dishonest respondents might have given positive answers although the reality was the opposite, especially in terms of attitudes and practices to prevent dengue infection.

Entomological Surveys

The pilot COMBI program was implemented in the Hulu Langat district in 2004 (Rozhan et al. 2006). Semi-permanent water containers, such as plant jars and flowerpot bases, were found to be the predominant *Aedes* breeding sites in Hulu Langat. To spread the message regarding precautionary action, 172 volunteers were recruited to distribute pamphlets and flashlights to 2,458 premises. Residents were instructed to illuminate water containers twice weekly and scrub those that contained larvae. The program started in May 2004 and ran for 16 weeks until September 2004. During this period, both the initial *Aedes* index and Breteau index of 5 were reduced to 0.96, indicating that the risk of dengue transmission was lower post-intervention (Halstead 2008). The predominant mosquito species appeared to be *Aedes albopictus*, comprising 80% (86 larvae) of the total larvae examined (108 larvae). Based on the entomological assessment, the COMBI program was successfully implemented for

TABLE 3: Characteristics of the included studies

Author, Year	Title	Objective	Study design	Study location	Sample size/ premise	Timeline/ intervention period
Rozhan et al. (2006)	The COMBI (Communication for Behavioural Impact) Program in the Prevention and Control of Dengue – The Hulu Langat Experience	To provide a brief background of COMBI and determine the unifying characteristics of Aedes breeding in the target community	Quantitative	Section 3 and Section 4 of Bandar Baru Bangi, Hulu Langat, Selangor	2,458 premises	May 2004–September 2004 (16 weeks)
Hod et al. (2013)	The COMBI Approach in Managing Dengue Cases in an Urban Residential Area, Nilai, Malaysia	To measure the effectiveness of the COMBI approach in the control of dengue cases in Taman Desa Kolej, Nilai, Negeri Sembilan	Quantitative	Taman Desa Kolej, Nilai, Negeri Sembilan	106 respondents	November 2011–March 2012 (14 weeks)
Mohammed Nawi et al. (2015)	Communication for Behavioural Impact (COMBI) Program in Dengue Prevention Evaluation: Mixed Method Approach	To evaluate the impact of the COMBI program in Hulu Langat (implemented in 2004)	Mixed method	- Section 3 and Section 4 of Bandar Baru Bangi, Hulu Langat, Selangor (target population) - Section 5 of Bandar Baru Bangi, Hulu Langat, Selangor (control population)	Target: 160 Control: 154 Total: 314 respondents	June 2008–December 2008
Suraiya et al. (2016)	COMBI Approach as Community-Based Intervention in Dengue Control through Leadership	To understand the characteristics of the communities that applied COMBI approaches actively as compared with other areas where activity levels have waned.	Qualitative	Multi-center (six states) - Sarawak: Taman Malihah II and Kg. Bako - Johor: Pasir Gudang and Kg. Melayu Majidee - Kelantan: Kg. Kandis Bachok and Kg. Baru Nelayan Tumpat - Penang: Kg. Binjai and Kg. Baru Sg. Ara Selangor: Taman Setia Klang and Sg. Ramal Dalam - Negeri Sembilan: Taman Tuanku Jaafar and Taman Enstek	112 respondents	October 2010–June 2011

TABLE 4: Summary of the retrieved articles

Author, Year	Level of knowledge, attitude, and practice	Entomological surveys	Factors associated with participation
Rozhan et al. (2006)	N/A	- Primary mosquito *Aedes albopictus* - Aedes index (%) Pre: 5.0 Post: 0.96 - Breteau index Pre: 5.0 Post: 0.96	N/A
Hod et al. (2013)	- Knowledge score, mean (SD) Pre: 21.9 (4.24) Post: 26.8 (4.28) p-value: <0.05 - Attitude score, mean (SD) Pre: 51.7 (7.75) Post: 52.3 (4.85) p-value: <0.05 - Practice score, mean (SD) Pre: 21.9 (4.74) Post: 22.5 (1.96) p-value: <0.05	- Primary mosquito *Aedes albopictus* - Indoor ovitrap index (%), median (IQR) Pre: 65.0 (26.0, 77.0) Post: 36.8 (27.3, 40.7) p-value: 0.237 - Outdoor ovitrap index (%), median (IQR) Pre: 27.8 (9.1, 38.5) Post: 20.0 (16.7, 39.1) p-value: 0.866	N/A
Mohammed Nawi et al. (2015)	- Knowledge score, mean (SD) Target: 12.66 (1.17) Control: 12.32 (1.62) p-value: 0.22 - Attitude score, mean (SD) Target: 35.59 (2.28) Control: 35.44 (2.74) p-value: 0.66 - Practice score, mean (SD) N/A	N/A	Continuous monitoring, commitment from the community and health authority, intensive campaigning or publicity, initiative by the local community, inspection by responsible authorities and appropriate human resources for monitoring
Suraiya et al. (2016)	N/A	N/A	Leadership and commitment, continuous publicity, and involvement of the coordinator

N/A: Not available

dengue prevention and control in the target population.

Hod et al. (2013) reached similar conclusions in their study, where entomological surveys showed that *Aedes albopictus* was the primary species in Nilai, comprising 31% (78 adult mosquitoes) of the total mosquitoes examined (223 adult mosquitoes). Both indoor and outdoor ovitrap surveillance showed a reduction in the ovitrap index post-intervention. Even though the COMBI program did not statistically significantly reduce the ovitrap index, the abundance of the *Aedes* mosquitoes in the living environment was still reduced after the intervention, indicating that people took responsibility for managing their surroundings, which might have contributed to unfavourable breeding conditions.

Factors Associated with COMBI Participation

The qualitative part of the study by Mohammed Nawi et al. (2015) included four respondents from the Hulu Langat District Health Office and 12 respondents from the target population who were involved with COMBI. A focal group discussion (FGD) was conducted with the respondents from the target population, while in-depth interviews were conducted with respondents from the Hulu Langat District Health Office. The respondents expressed that COMBI had provided exposure to and helped the community with dengue prevention and control. In the short term, COMBI was a successful program. Nevertheless, the program failed to sustain itself because there was no continuous monitoring, commitment from community and health authorities, intensive campaigning or publicity, or initiative by the local community; irregular inspections by responsible authorities and a lack of human resources for conducting the program and monitoring its progression also contributed.

To mobilise the community and ensure the sustainability of COMBI operations, Suraiya et al. (2016) found a requirement for strong leadership and commitment. Factors deterring strong leadership included migration, holding various portfolios, having opposing political views, and feeling unappreciated. The inability of leaders to push the local COMBI committees to conduct COMBI activities resulted in poor management in curbing dengue transmission. Moreover, regardless of whether the sites were active or inactive with respect to COMBI, continuous publicity was lacking. This was a crucial point since the communities perceived the discontinuation of COMBI-related publicity as reflecting the discontinuation of COMBI activities and were no longer concerned with dengue, which could have impacted source-reduction activities. Moreover, according to the respondents, the continuous involvement of the coordinator (health personnel) was important in getting support from the community.

Validity Threat and Confidence in the Results

Most studies assessed short-term KAP improvements without longitudinal follow-up, which might overestimate the sustainability of the intervention's impact. Limited resources and inconsistent community engagement strategies also emerged as frequent limitations, highlighting sustainability as a significant challenge for COMBI interventions. Collectively, these factors point to shared limitations in both study design and intervention execution, suggesting that the COMBI approach can be effective in certain contexts, but its impact may diminish without continuous community participation and resource allocation.

Despite the noted validity threats, the studies reviewed that providing a reasonably robust body of evidence in supporting the role or the COMBI approach in improving KAP levels and reducing entomological indices in targeted communities. Consistent patterns in KAP improvement and reductions in Aedes indices during active intervention phases suggest that COMBI has tangible benefits for dengue prevention. However, these outcomes must be interpreted with caution, considering the design limitations and external factors that may have influenced results. Taken together, these findings underscore the potential of COMBI as a valuable community mobilisation tool for dengue prevention, while also highlighting the importance of addressing sustainability challenges and incorporating broader, randomised studies to strengthen future evidence.

Risk of Bias

The studies included in this systematic review presented a low to moderate risk of bias. Selection bias was common, as participants were often chosen from specific urban or suburban areas, limiting the representativeness of the findings. Additionally, self-administered questionnaires used in some studies may have introduced response bias, where participants may have provided socially desirable answers rather than accurate reflections of their KAP. Efforts to control confounding factors were minimal, suggesting that the observed outcomes could have been influenced by other variables not accounted for, such as concurrent public health interventions.

Consistency

Overall, the findings across studies were reasonably consistent in demonstrating positive short-term effects of the COMBI intervention on KAP improvement and entomological indices. Despite variations in study settings and methodologies, most studies reported reductions in vector indices and increased KAP levels following COMBI implementation, especially during active phases of intervention. However, the results were inconsistent regarding the sustainability of these effects, with some studies noting a decline in impact post-intervention. This consistency in initial outcomes suggests COMBI's potential effectiveness, though the variation in long-term sustainability highlights the need for continuous community engagement and resources.

Precision

The absence of confidence intervals or detailed variance metrics in some studies further limits the precision and generalisability of the results. This lack of precision suggests that trends in effectiveness are observed, definitive conclusions should be interpreted cautiously.

Reporting Bias

The potential for reporting bias was present, given that most studies included were published in English, there may be a language bias, excluding relevant local studies or gray literature in non-English sources. This focus may skew the body of evidence towards positive results, underscoring the importance of accessing diverse sources to provide a comprehensive view of COMBI's effectiveness.

Plausible Confounding that would Change the Observed Effect

Several confounding factors, such as socioeconomic status, educational

background, and prior exposure to dengue prevention campaigns, may have influenced the observed effects of the COMBI interventions. Few studies controlled for these factors, which limits the ability to attribute improvements in KAP or vector indices solely to COMBI activities. The presence of additional dengue prevention efforts by local health authorities or Non-Governmental Organizations (NGOs) in some communities also poses a plausible confounding factor that could inflate the intervention's apparent effectiveness.

Strength of Association

Despite these limitations, the observed associations between COMBI interventions and improvements in KAP and reductions in vector indices were moderately strong. Studies consistently reported that active engagement and mobilisation through COMBI led to immediate, measurable improvements in targeted outcomes, suggesting a meaningful relationship between community-driven efforts and dengue prevention. However, given the limitations in study design and data precision, these associations should be interpreted with caution until further evidence from randomised controlled trials or studies with stronger methodological rigor become available.

DISCUSSION

This systematic review provides a comprehensive assessment of the COMBI approach's effectiveness in dengue prevention and control in Malaysia, analysing both intervention outcomes and factors influencing community participation. By synthesising evidence from studies conducted between 2001 and 2023, this review evaluates the role of COMBI in enhancing KAP while reducing vector indices. This systematic approach also allows for a critical examination of methodological quality and potential biases across studies, providing insights into areas that may impact the validity and sustainability of COMBI interventions. The evidence on the effectiveness of the COMBI approach in dengue prevention in Malaysia demonstrates promising short-term outcomes, particularly in improving KAP and reducing entomological indices. The studies included in this review consistently report positive short-term impacts during the active intervention period, indicating that COMBI mobilises communities effectively to address dengue transmission.

The study of KAP is an essential process in the prevention and control of dengue. Several studies reported significant improvement in the KAP level immediately after the implementation of community-based interventions for controlling dengue (Ahbirami & Zuharah 2020; Elsinga et al. 2018; Khun & Manderson 2007; Wong et al. 2015). The incorporation of health promotion into a more comprehensive strategy for behavioural modification such as the COMBI method, which includes behavioural models as well as communication and marketing theory and practice, was thought to improve the KAP level for dengue (Kumaran et al. 2018). Our review found different levels of KAP after the implementation of the COMBI program. The KAP scores increased post intervention in Nilai (Hod et al. 2013). However, the study in Hulu Langat concluded that the COMBI program did not play a major role in changing perceptions of and behaviour toward dengue prevention and control (Mohammed Nawi et al. 2015). The gold standard for evaluating interventions has been a pre- and post-measurement design with randomised controls (Richardson & Rothstein 2008). Hence, ideally, the effectiveness of the COMBI program in Hulu Langat would be

judged with reference to information collected before program implementation, including data on KAP study.

The *Aedes albopictus* was the predominant species in Nilai and Hulu Langat; this mosquito is also the vector for other infections posing severe public health problems, including chikungunya (Erin Staples et al. 2009; Weaver & Lecuit 2015), Zika (Petersen et al. 2016), and yellow fever (Barnett 2007). Three entomological indices were used as outcome measures in the reviewed studies: the *Aedes* index, Breteau index and ovitrap index. All three indices showed a reduction post-COMBI implementation. Similar findings were also reported by other studies (Arunachalam et al. 2012; Castro et al. 2012; Wai et al. 2012). However, these indices do not represent the adult vector population, and hence, the risk of dengue transmission (Azil et al. 2011). Therefore, the adoption of adult dengue vector sampling by all vector surveillance programs is recommended as part of program effectiveness assessment (Bowman et al. 2014).

This evidence must be interpreted with caution due to several methodological limitations affecting the strength and generalisability of the findings. First, most studies relied on cross-sectional designs or lacked randomised controlled trials (RCTs), which are the gold standard for establishing causality. This limitation restricts the ability to draw firm conclusions about COMBI's long-term impact. While there is consistency in the positive short-term effects of COMBI, the limited follow-up data raises questions about the sustainability of these improvements once active intervention ceases. Second, potential biases such as selection bias and self-reported measures may have influenced the results. For instance, the selection of study participants from specific urban or suburban settings may limit generalisability across different population groups and geographical contexts.

Additionally, some studies employed self-administered questionnaires, which might introduce response bias if participants reported socially desirable behaviours rather than their actual practices. Despite these limitations, the moderate association observed between COMBI implementation and immediate improvements in KAP and reductions in vector indices suggest meaningful relationship between community-driven efforts and dengue prevention. However, the strength of this association remains uncertain without further evidence from cluster RCTs or studies with longer follow-up periods to validate sustained outcomes.

The effectiveness of the COMBI approach in dengue prevention is closely tied to the community's engagement and sustained participation. This review identified several critical factors influencing COMBI participation, including leadership, resource availability, community commitment, and ongoing publicity. These factors are essential in mobilising communities to actively engage in dengue prevention activities, as well as in fostering a sense of ownership over the program.

Leadership and commitment from both community leaders and health coordinators emerged as pivotal for maintaining active participation. Leaders with strong communication skills and a genuine commitment to public health goals can effectively rally community members, ensuring a more sustained impact (Marha et al. 2020; Zahir et al. 2016). However, challenges such as frequent leader turnover, competing priorities, and political differences often hinder the consistency of leadership, leading to periods of reduced community involvement. Hence, shared authority and responsibility among the community offer better prospects for long-

term success (Mazrura et al. 2010).

The availability of resources also plays a crucial role in sustaining COMBI activities. The review revealed that limited funding, insufficient human resources, and sporadic oversight from health authorities lead to gaps in program execution and monitoring. Communities lacking in these essential resources often struggle to maintain momentum, which compromises the long-term sustainability of COMBI initiatives (Cooper et al. 2021). Moreover, continuous publicity and community reminders were found to be essential for keeping dengue prevention top of mind for residents. When publicity efforts wane, community awareness and motivation to participate in dengue control activities tend to diminish. This underscores the need for regular, visible communication from health authorities to reinforce the importance of individual and collective actions in dengue prevention. In sum, strong leadership, adequate resources, consistent health department involvement, and ongoing community-focused communication are critical to sustaining participation in COMBI interventions. Addressing these factors could enhance the durability and effectiveness of COMBI as a community-driven strategy for dengue prevention in Malaysia.

As the conventional implementation of COMBI requires the involvement of the health department and various related agencies, substantial funds, and excellent leadership at the community level, new strategies are needed to eliminate these challenges so that COMBI can be delivered directly to everyone quickly, easily and at no cost. Thus, COMBI activities can be implemented by individuals without the need for reminders, invitations, or guidance from the COMBI committee in their respective localities. In line with the development of mobile devices, various apps have been created to assist disease surveillance (Mtema et al. 2016), prevention activities (Crane et al. 2015), diagnosis (Meyer et al. 2018), as well as treatment management (Morrissey et al. 2018). They have the potential to facilitate the dissemination of knowledge and good practices by reducing transaction costs, providing large populations with instant access to information and indirectly improving public health services (Aker & Mbiti 2010). Hence, digitalising COMBI via mobile apps is a strategy that can be explored to ensure its effectiveness and sustainability.

Limitation

As with any research work, this systematic review is not without limitations. Despite a rigorous search, we only found four studies conducted in Malaysia, where COMBI is exclusively implemented for dengue prevention at the community level. Excluding other potential information sources in the earlier phase, such as grey literature in the form of government and other reports, limited our access to data on COMBI implementation in Malaysia. Moreover, language bias must also be considered as we only included publications in English.

Despite these limitations, to the best of our knowledge, this is the first systematic review synthesising evidence on the effectiveness of the COMBI approach for dengue prevention and factors associated with participation therein by local communities. Since the COMBI approach has been widely implemented throughout Malaysia, we call for more cluster randomised controlled trials to determine the effectiveness of this intervention by measuring its impact on KAP and perception, entomological indices, as well as dengue infection or dengue incidence. This will increase the reliability of our findings and facilitate future meta-analyses.

CONCLUSION

This systematic review provides insights into the effectiveness of COMBI in dengue prevention and factors associated with participation therein. Even though the available evidence is limited, the COMBI approach did improve the KAP and reduce the presence of vectors during the active implementation period. Our findings also highlighted several key factors related to participation, including appropriate human resource management and continuous publicity from the health department as well as strong leadership and commitment from both the chairman and the coordinator of COMBI. Thus, the information in this review can help policymakers devise new strategies to improve COMBI implementation, maintain active participation therein and achieve sustainability. Nevertheless, more well-conducted cluster randomised controlled trials are needed to provide evidence of real-life impact. Future trials should include measurements of COMBI's impact on KAP and perception, entomological indices and dengue infection.

Author contributions: Conceptualisation: MRH, AFNAH; Methodology: AFNAH, MRH, RH, KYS, NKMA; Data curation & format analysis: AFNAH, MRH; Supervision: MRH; Validation: RH, KYS, NKMA; Writing original draft: AFNAH; Writing review & editing: RD, SSSAR, MAIAZ, MNJ, SAMH, QMG. All authors read and approved the final manuscript. The authors alone are responsible for the views expressed in this article and they do not necessarily represent the views, decisions, or policies of the institutions with which they are affiliated. All authors read and approved the final manuscript.

Data availability statement: All relevant data are within the manuscript.

Funding: This research is supported by the Universiti Kebangsaan Malaysia Research University Grant (GUP-2019-081). The funder had no role in study design, data collection and analysis, decision to publish or preparation of the manuscript.

Acknowledgement: The authors are grateful to the Department of Public Health Medicine, Faculty of Medicine, Universiti Kebangsaan Malaysia for the technical support.

Competing interests: The authors declare no conflicts of interest.

REFERENCES

AbuBakar, S., Sharifa Ezat, W.P., Kastner, R., Oliver, L., Lim, S.H., Hanley, R., Gallagher, E. 2022. Epidemiology (2012-2019) and costs (2009-2019) of dengue in Malaysia: A systematic literature review. *Int J Infect Dis* **124**: 240-7.

Ahbirami, R., Zuharah, W.F. 2020. School-based health education for dengue control in kelantan, malaysia: Impact on knowledge, attitude and practice. *PLoS Negl Trop Dis* **14**(3): e0008075.

Aker, J.C., Mbiti, I.M. 2010. Mobile phones and economic development in Africa. *J Econ Perspect* **24**(3): 207-32.

Arunachalam, N., Tyagi, B.K., Samuel, M., Krishnamoorthi, R., Manavalan, R., Tewari, S.C., Ashokkumar, V., Kroeger, A., Sommerfeld, J., Petzold, M. 2012. Community-based control of Aedes aegypti by adoption of eco-health methods in Chennai City, India. *Pathog Glob Health* **106**(8): 488-96.

Azil, A.H., Li, M., Williams, C.R. 2011. Dengue vector surveillance programs: A review of methodological diversity in some endemic and epidemic countries. *Asia Pac J Public Health* **23**(6): 827-42.

Banneheke, H., Paranavitane, S., Jayasuriya, V., Banneheka, S. 2016. Perceived risk of dengue in ones' living environment as a determinant of behaviour change through social mobilization and communication: Evidence from a high risk area in Sri Lanka. *J Arthropod Borne Dis* **10**(3): 392-402.

Barnett, E.D. 2007. Yellow fever: Epidemiology and prevention. *Clin Infect Dis* **44**(6): 850-6.

Bhatt, S., Gething, P.W., Brady, O. J., Messina, J. P., Farlow, A.W., Moyes, C.L., Drake, J.M., Brownstein, J.S., Hoen, A.G., Sankoh, O.,

Myers, M.F., George, D.B., Jaenisch, T., Wint, G.R., Simmons, C.P., Scott, T.W., Farrar, J.J., Hay, S.I. 2013. The global distribution and burden of dengue. *Nature* **496**: 504-7.

Bigio, J., Braack, L., Chea, T., Set, S., Suon, S., Echaubard, P., Hustedt, J., Debackere, M., Ramirez, B., Prasetyo, D.B., Bunleng, S., Wharton-Smith, A., Hii, J. 2022. Entomological outcomes of cluster-randomised, community-driven dengue vector-suppression interventions in Kampong Cham province, Cambodia. *PLoS Negl Trop Dis* **16**(1): e0010028.

Bonnet, E., Fournet, F., Benmarhnia, T., Ouedraogo, S., Dabiré, R., Ridde, V. 2020. Impact of a community-based intervention on Aedes aegypti and its spatial distribution in Ouagadougou, Burkina Faso. *Infect Dis Poverty* **9**(1): 61.

Bowman, L.R., Runge-Ranzinger, S., McCall, P.J. 2014. Assessing the relationship between vector indices and dengue transmission: A systematic review of the evidence. *PLoS Negl Trop Dis* **8**(5): e2848.

Bramer, W.M., Giustini, D., De Jonge, G.B., Holland, L., Bekhuis, T. 2016. De-duplication of database search results for systematic reviews in EndNote. *J Med Libr Assoc* **104**(3): 240-3.

Caprara, A., Lima, J.W., Peixoto, A.C., Motta, C.M., Nobre, J.M., Sommerfeld, J., Kroeger, A. 2015. Entomological impact and social participation in dengue control: A cluster randomized trial in Fortaleza, Brazil. *Trans R Soc Trop Med Hyg* **109**(2): 99-105.

Castro, M., Sánchez, L., Pérez, D., Carbonell, N., Lefèvre, P., Vanlerberghe, V., Van der Stuyft, P. 2012. A community empowerment strategy embedded in a routine dengue vector control programme: A cluster randomised controlled trial. *Trans R Soc Trop Med Hyg* **106**(5): 315-21.

Cooper, J., Murphy, J., Woods, C., Van Nassau, F., McGrath, A., Callaghan, D., Carroll, P., Kelly, P., Murphy, N., Murphy, M., Irish Physical Activity Research Collaboration (I-PARC). 2021. Barriers and facilitators to implementing community-based physical activity interventions: a qualitative systematic review. *Int J Behav Nutr Phys Act* **18**(1): 118.

Crane, D., Garnett, C., Brown, J., West, R., Michie, S. 2015. Behaviour change techniques in popular alcohol reduction apps: Content analysis. *J Med Internet Res* **17**(5): e118.

Elsinga, J., Schmidt, M., Lizarazo, E.F., Vincenti-Gonzalez, M.F., Velasco-Salas, Z.I., Arias, L., Burgerhof, J.G.M., Tami, A. 2018. Knowledge, attitudes, and preventive practices regarding dengue in Maracay, Venezuela. *Am J Trop Med Hyg* **99**(1): 195-203.

Elsinga, J., Van Der Veen, H.T., Gerstenbluth, I., Burgerhof, J.G.M., Dijkstra, A., Grobusch, M.P., Tami, A., Bailey, A. 2017. Community participation in mosquito breeding site control: An interdisciplinary mixed methods study in Curaçao. *Parasit Vectors* **10**(1): 434.

Erin Staples, J., Breiman, R.F., Powers, A.M. 2009. Chikungunya fever: An Epidemiological Review of a Re-Emerging Infectious Disease. *Clin Infect Dis* **49**(6): 942-8.

Halstead, S.B. 2008. Dengue virus-mosquito interactions. *Annu Rev Entomol* **53**(1): 273-91.

Hanh, T., Hill, P., Kay, B., Quy, Y. 2009. Development of a framework for evaluating the sustainability of community-based dengue control projects. *Am J Trop Med Hyg* **80**(2): 312-8.

Heintze, C., Garrido, M.V., Kroeger, A. 2007. What do community-based dengue control programmes achieve? A systematic review of published evaluations. *Trans R Soc Trop Med Hyg* **101**(4): 317-25.

Hod, R., Othman, H., Jemain, N.A., Sahani, M., Udin, K., Ali, Z. M., Choy, E. A., Suli, Z. 2013. The COMBI approach in managing dengue cases in an urban residential area, Nilai, Malaysia. *Int J Public Health Res* **3**(2): 347-52.

Hong, Q.N., Fàbregues, S., Bartlett, G., Boardman, F., Cargo, M., Dagenais, P., Gagnon, M.P., Griffiths, F., Nicolau, B., O'Cathain, A., Rousseau, M.C., Vedel, I., Pluye, P. 2018. The mixed methods appraisal tool (MMAT) version 2018 for information professionals and researchers. *Educ Inform* **34**(4): 285-91.

Hustedt, J., Doum, D., Keo, V., Ly, S., Sam, B.L., Chan, V., Alexander, N., Bradley, J., Liverani, M., Prasetyo, D., Rachmat, A., Shafique, M., Lopes, S., Rithea, L., Hii, J. 2021. Field efficacy of larvivorous fish and pyriproxyfen combined with community engagement on dengue vectors in Cambodia: A randomized controlled trial. *Am J Trop Med Hyg* **105**(5): 1265-76.

Jane Ling, M.Y., Halim, A.F.N.A., Ahmad, D., Ramly, N., Hassan, M.R., Syed Abdul Rahim, S.S., Saffree Jeffree, M. Omar, A., Hidrus, A. 2023. Rabies in Southeast Asia: A systematic review of its incidence, risk factors and mortality. *BMJ Open* **13**(5): e066587.

Kalayanarooj, S., Rothman, A.L., Srikiatkhachorn, A. 2017. Case management of dengue: Lessons learned. *J Infect Dis* **215**(Suppl 2): S79-88.

Khun, S., Manderson, L. 2007. Community and school-based health education for dengue control in rural Cambodia: A process evaluation. *PLoS Negl Trop Dis* **1**(3): e143.

Kittayapong, P., Thongyuan, S., Olanratmanee, P., Aumchareoun, W., Koyadun, S., Kittayapong, R., Butraporn, P. 2012. Application of eco-friendly tools and eco-biosocial strategies to control dengue vectors in urban and peri-urban settings in Thailand. *Pathog Glob Health* **106**(8): 446-54.

Kumaran, E., Doum, D., Keo, V., Sokha, L., Sam, B. L., Chan, V., Alexander, N., Bradley, J, Liverani, M., Prasetyo, D.B., Rachmat, A., Lopes, S., Hii, J., Rithea, L., Shafique, M., Hustedt, J. 2018. Dengue knowledge, attitudes and practices and their impact on community-based vector control in rural Cambodia. *PLoS Negl Trop Dis* **12**(2): e0006268.

Lima, E.P., Goulart, M.O.F., Rolim Neto, M.L. 2015. Meta-analysis of studies on chemical, physical and biological agents in the control of *Aedes aegypti* infectious disease epidemiology. *BMC Public Health* **15**(858): 1-14.

Lin, H., Liu, T., Song, T., Lin, L., Xiao, J., Lin, J., He, J., Zhing, H., Hu, W., Deng, A., Peng, Z., Ma, W., Zhang, Y. 2016. Community involvement in dengue outbreak control: An integrated rigorous intervention strategy. *PLoS Negl Trop Dis* **10**(8): e0004919.

Liverani, M., Charlwood, J.D., Lawford, H., Yeung, S. 2017. Field assessment of a novel spatial repellent for malaria control: A feasibility and acceptability study in Mondulkiri, Cambodia. *Malar J* **16**: 412.

Marha, D.A., Fatah, M.Z., Winarko, W. 2020. The role of health workers and community leaders to prevent dengue hemorrhagic fever in Magetan, East Java. *Jurnal Promkes: The Indonesian Journal of Health Promotion and Health Education* **8**(2): 172-81.

Mazrura, S., Hod, R., Hidayatulfathi, O., Zainudin, M.A., Naim, M.R., Nadia, A.M.N. 2010. Community vulnerability on dengue and its association with climate variability in Malaysia. *Malaysian J Public Health Med* **10**(2): 25-34.

Meyer, A.N.D., Thompson, P.J., Khanna, A., Desai, S., Mathews, B.K., Yousef, E., Kusnoor, A.V., Singh, H.2018. Evaluating a mobile application for improving clinical laboratory test ordering and diagnosis. *J Am Med Inform Assoc* **25**(7): 841-7.

Mitchell-Foster, K., Ayala, E.B., Breilh, J., Spiegel, J., Wilches, A.A., Leon, T.O., Delgado, J.A. 2015. Integrating participatory community mobilization processes to improve dengue prevention: An eco-bio-social scaling up of local success in Machala, Ecuador. *Trans R Soc Trop Med Hyg* **109**(2): 126-33.

Ministry of Health (MOH). 2022. National Dengue Prevention and Control Strategic Plan 2022-2026. Ministry of Health Malaysia.

Mohammed Nawi, A., Ismail, A., Mohamed, A. 2015. Communication for behavioural impact (COMBI) program in dengue prevention evaluation: Mixed methods approach. *Int Med J* **22**(5): 367-70.

Mohd-Zaki, A.H., Brett, J., Ismail, E., L'Azou, M. 2014. Epidemiology of dengue disease in Malaysia (2000–2012): A systematic literature review. *PLoS Negl Trop Dis* **8**(11): e3159.

Morrissey, E.C., Casey, M., Glynn, L.G., Walsh, J.C., Molloy, G.J. 2018. Smartphone apps for improving medication adherence in hypertension: Patients' perspectives. *Patient Prefer Adherence* **12**: 813-22.

Mtema, Z., Changalucha, J., Cleaveland, S., Elias, M., Ferguson, H.M., Halliday, J.E.B., Haydon, D. T., Jaswant, G., Kazwala, R., Killeen, G.F., Lembo, T., Lushasi, K., Malishee, A.D., Mancy, R., Maziku, M., Mbunda, E.M., Mchau, G.J., Murray-Smith, R., Rysava, K., Said, K., Sambo, M., Shayo, E., Sikana, L., Townsend, S.E., Urassa, H., Hampson, K. 2016. Mobile phones as surveillance tools: Implementing and evaluating a large-scale intersectoral surveillance system for rabies in Tanzania. *PLoS Med* **13**(4): e1002002.

Munn, Z., Stern, C., Aromataris, E., Lockwood, C., Jordan, Z. 2018. What kind of systematic review should I conduct? A proposed typology and guidance for systematic reviewers in the medical and health sciences. *BMC Med Res Methodol* **18**: 5.

Murray, N.E.A., Quam, M.B., Wilder-Smith, A. 2013. Epidemiology of dengue: Past, present and future prospects. *Clin Epidemiol* **5**(1): 299-309.

Othman, H., Nordin Saiful, A., Abdul Rashid, N., Hisham Abas Mohamed, B., Hod, R., Sahani, M. 2017. Dengue-free community as an approach for understanding the value and challenges of inter-agencies partnerships in an intervention program. *Int J Community Med Public Health* **4**(6): 1819-26.

Ouédraogo, S., Benmarhnia, T., Bonnet, E., Somé, P.A., Barro, A.S., Kafando, Y., Soma, D.D., Dabiré, R.K., Saré, D., Fournet, F., Ridde, V. 2018. Evaluation of effectiveness of a community-based intervention for control of dengue virus vector, Ouagadougou, Burkina Faso. *Emerg Infect Dis* **24**(10): 1859-67.

Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., Shamseer, L., Tetzlaff, J.M., Akl, E.A., Brennan, S.E., Chou, R. 2021. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ* **372**: n71.

Pang, T., Mak, T.K., Gubler, D.J. 2017. Prevention and control of dengue-the light at the end of the tunnel. *Lancet Infect Dis* **17**(3): e79-87.

Parks, W.J., Lloyd, L.S., Nathan, M.B., Hosein, E., Odugleh, A., Clark, G.G., Gubler, D.J., Prasittisuk, C., Palmer, K., San Martin, J.L., Siversen, S.R., Dawkins, Z., Renganathan, E. 2004. International experiences in social mobilization and communication for dengue prevention and control. *Dengue Bulletin* **28**(Suppl.).

Pérez, D., Lefèvre, P., Castro, M., Toledo, M. E., Zamora, G., Bonet, M., Van der Stuyft, P.

2013. Diffusion of community empowerment strategies for Aedes aegypti control in Cuba: A muddling through experience. *Soc Sci Med* **84**: 44-52.

Petersen, L.R., Jamieson, D.J., Powers, A.M., Honein, M.A. 2016. Zika Virus. *N Engl J Med* **374**(16): 1552-63.

Renganathan, E., Parks, W., Lloyd, L., Nathan, M. B., Hosein, E., Odugleh, A., Clark, G.G., Gubler, D.J., Prasittisuk, C., Palmer, K., San Martin, J.L. 2003. Towards sustaining behavioural impact in dengue prevention and control. *Dengue Bulletin* **27**: 6-12.

Richardson, K.M., Rothstein, H.R. 2008. Effects of occupational stress management intervention programs: A meta-analysis. *J Occup Health Psychol* **13**(1): 69-93.

Rose Nani, M. 2015. Dengue Incidence and the prevention and control program in Malaysia. *IIUM Medical Journal Malaysia* **14**(1): 5-9.

Rozhan, S., Jamsiah, M., Rahimah, A., Ang, K. 2006. The COMBI (Communication for Behavioural Impact) in the prevention and control of dengue-The Hulu Langat experience. *J Community Health* **12**(1): 19-32.

Scott, T.W., Morrison, A.C. 2010. Vector dynamics and transmission of dengue virus: implications for dengue surveillance and prevention strategies: vector dynamics and dengue prevention. *Curr Top Microbiol Immunol* **338**: 115-28.

Shafique, M., Lopes, S., Doum, D., Keo, V., Sokha, L., Sam, B., Vibol, C., Alexander, N., Bradley, J., Liverani, M., Hii, J., Rithea, L., Aryal, S., Hustedt, J. 2019. Implementation of guppy fish (*Poecilia reticulata*), and a novel larvicide (Pyriproxyfen) product (Sumilarv 2MR) for dengue control in Cambodia: A qualitative study of acceptability, sustainability and community engagement. *PLoS Neg Trop Dis* **13**(11): e0007907.

Simmons, C.P., Farrar, J.J., Chau, N., van V., Wills, B. 2012. Dengue. *N Engl J Med* **366**(15): 1423-32.

Sombié, I., Degroote, S., Somé, P.A., Ridde, V. 2020. Analysis of the implementation of a community-based intervention to control dengue fever in Burkina Faso. *Implement Sci* **15**(1): 32.

Stanaway, J.D., Shepard, D.S., Undurraga, E.A., Halasa, Y.A., Coffeng, L.E., Brady, O.J., Hay, S.I., Bedi, N., Bensenor, I.M., Castañeda-Orjuela, C.A., Chuang, T.W., Gibney, K.B., Memish, Z.A., Rafay, A., Ukwaja, K.N., Yonemoto, N., Murray, C.J.L. 2016. The global burden of dengue: An analysis from the Global Burden of Disease Study 2013. *Lancet Infect Dis* **16**(6): 712-23.

Suhaili, M., Hosein, E., Mokhtar, Z., Ali, N., Palmer, K., Isa, M.M. 2004. Applying communication-for-behavioural-impact (COMBI) in the prevention and control of dengue in Johor Bahru, Johor, Malaysia. *Dengue Bulletin* **28**: 39-43.

Suraiya, S., Zaman, S., Shahnaz, M., Faizal, B. & Asiah, M. 2016. COMBI approach as community-based intervention in dengue control through leadership. *Br J Educ Soc Behav Sci* **13**(3): 1-8.

Tapia-Conyer, R., Méndez-Galván, J. Burciaga-Zúñiga, P. 2012. Community participation in the prevention and control of dengue: The patio limpio strategy in Mexico. *Paediatr Int Child Health* **32**(Suppl 1): 10-3.

Toledo Romani, M.E., Vanlerberghe, V., Perez, D., Lefevre, P., Ceballos, E., Bandera, D., Baly Gil, A., Van der Stuyft, P. 2007. Achieving sustainability of community-based dengue control in Santiago de Cuba. *Soc Sci Med* **64**(4): 976-88.

Undurraga, E.A., Halasa, Y.A., Shepard, D.S. 2013. Use of expansion factors to estimate the burden of dengue in Southeast Asia: A systematic analysis. *PLoS Neg Trop Dis* **7**(2): e2056.

Vanlerberghe, V., Toledo, M.E., Rodríguez, M., Gomez, D., Baly, A., Benitez, J.R., Van Der Stuyft, P. 2009. Community involvement in dengue vector control: Cluster randomised trial. *BMJ* **338**: b1959.

Wai, K.T., Htun, P.T., Oo, T., Myint, H., Lin, Z., Kroeger, A., Sommerfeld, J., Petzold, M. 2012. Community-centred eco-bio-social approach to control dengue vectors: An intervention study from Myanmar. *Pathog Glob Health* **106**(8): 461-8.

Weaver, S.C., Lecuit, M. 2015. Chikungunya virus and the global spread of a mosquito-borne disease. *N Engl J Med* **372**(13): 1231-9.

World Health Organization. 2008. *Asia-Pacific Dengue Strategic Plan (2008-2015). World Health Organization*.

World Health Organization. 2009. Dengue guidelines for diagnosis, treatment, prevention and control: New edition. *World Health Organization*.

World Health Organization. 2012a. Handbook for integrated vector management. *World Health Organization*.

World Health Organization. 2012b. Communication for behavioural impact (COMBI): A toolkit for behavioural and social communication in outbreak response. *World Health Organization*.

World Health Organization. 2017. Dengue vaccine: WHO position paper, July 2016 – recommendations. *Vaccine* **35**(9): 1200-1.

World Health Organization. 2024. Dengue and severe dengue. *World Health Organization*. https://www.who.int/news-room/fact-sheets/detail/dengue-and-severe-dengue [Accessed 2 January 2024]

Wong, L.P., Mahavera, S., Shakir, M., Atefi, N., Abubakar, S. 2015. Factors affecting dengue prevention practices: Nationwide survey of the Malaysian public. *PLoS ONE* **10**(4): e0122890.

Yi, S., Simler, K., Loh, W.S., Tan Wei, K. 2020. Who is

keeping score? Estimating the number of foreign workers in Malaysia. *World Bank Group*.

Zahir, A., Ullah, A., Shah, M., Mussawar, A. 2016. Community participation, dengue fever prevention and practices for control in swat, Pakistan. *Int J MCH AIDS* **5**(1): 39-45.